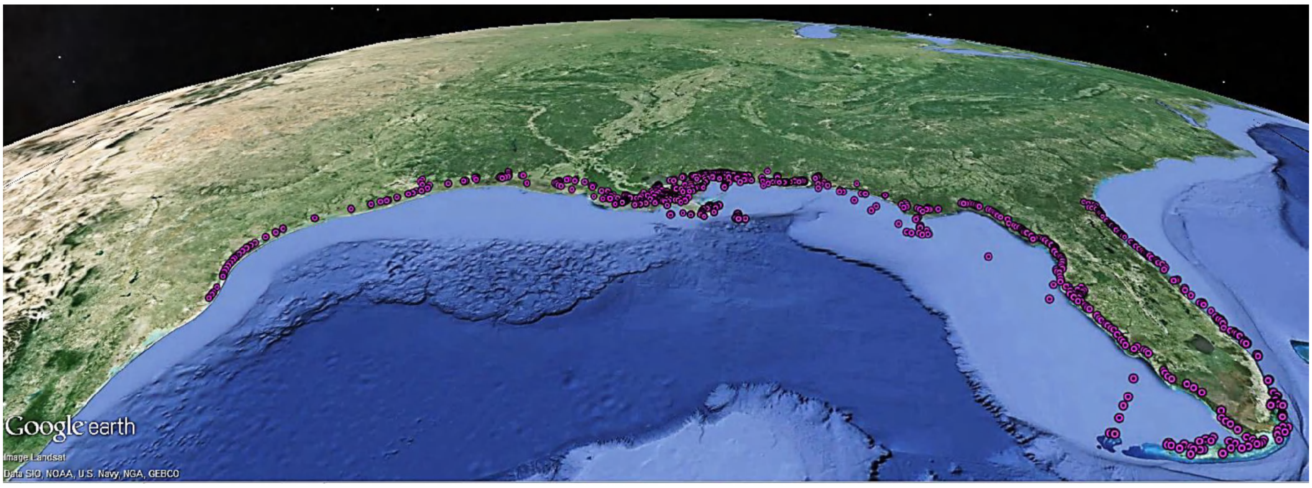
Forensic Assessment of 2010 Deepwater Horizon Nearshore Water Samples



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Cover image of all nearshore water data locations as displayed on Google Earth.

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Executive Summary

The Natural Resource Damage Assessment (NRDA) nearshore water data set derives primarily from small-boat, shallow-water sampling efforts and collections from the shore (as opposed to the larger vessel of opportunity cruises conducted offshore in deeper waters – Payne and Driskell 2015a). Sampling comprises all near-coastal samples obtained between April 2010 and August 2011, including those from barrier islands and embayments, as well as those proximal to mainland shorelines. In appendixes, BP's extensive, independent (without Trustee involvement) Nearshore Gulf of Mexico program (NGOM) and three other programs are also reviewed.

- From the 995 forensically-reviewed NRDA nearshore water samples analyzed by both Alpha Analytical and TDI Laboratory, 361 were considered matches to MC252, 85 were other oils and 549 were either indeterminate or clean.
- Dissolved-phase patterns dominated in 142 of the MC252 matched samples while an additional 198 were considered unresolved phases of MC252 oil. Only 21 of the matched samples were considered to have whole-oil, particulate patterns that most likely came from re-suspended oiled sediments.
- The scarcity of particulate oil and dominance of dissolved oil signals suggests that, unlike the offshore sampling encountering actual oil droplets in transit to or from the surface, these nearshore water samples primarily comprised "re-oiling" events, with dissolved components leaching from nearby previously deposited sources.
- Occasionally, and even within the highly spill-contaminated Barataria Bay, clean-water nearshore samples were encountered.
- BP's 2,908 NGOM samples, a time series sampled weekly between June and December 2010 at 152 fixed sites across the Gulf coast, contained only 9 matches, 84 "other oils" and 2,766 either indeterminate or clean. These data are from slightly farther offshore than the shoreline and shoreline-adjacent samples covered in the body of this report.

As a result of finding mostly dissolved- or indeterminate-phase oiled water samples rather than whole oil in nearshore waters, the forensic methods differed substantially from the hopane-balance and weathered-profile matching techniques used for particulate samples in the offshore waters forensic process (Payne and Driskell 2015b). Instead, these nearshore reviews relied heavily on a sample's proximity to previously confirmed forensic matches in other, more definitive, matrices and studies (i.e., the nearshore-sediments and stranded-oil matched samples that had biomarkers for verification (Emsbo-Mattingly 2015 and Stout 2015), and the Shoreline Cleanup and Assessment Techniques (SCAT) shoreline categories assigned by the DWH response, based on visual oiling). Away from urban areas, the presence of dispersant indicators was also relevant. Two other potentially confirming matrices were available, pom-pom and tissue collections, but were too scarce to be useful.

The interpretive scenario for oiled nearshore samples is that active landfall oiling had already occurred prior to collecting these samples. As a result, the data show the dissolved PAH components coming off the residual stranded (or sunken) oil. The few samples with particulate components were likely from

resuspension events. Dispersant markers were present in some samples suggesting encapsulation and transport with the oil.

Introduction

The Deepwater Horizon (DWH) event began to discharge oil on April 20, 2010 but according to aerial imagery, slicks did not significantly reach landfall until mid-May. From shoreline oiling observations (SCAT) and satellite readings (SAR), along with stranded tarballs, nearshore sediments, and pom-pom collection devices, the DWH-impacted shorelines have been well defined (Emsbo-Mattingly 2015; and Stout, 2015). The goal of this study was to look for hydrocarbons in waters adjacent to shorelines or sediment collections to determine nearshore water column exposures from MC252 oil. In addition to the data analyzed at Alpha Analytical Laboratory (Mansfield, MA), earlier collections analyzed by TDI Brooks Laboratory (College Station, TX) are included as reported in NOAA DIVER. In appendixes, BP's extensive, independent Nearshore Gulf of Mexico program (NGOM) and three other programs are reviewed.

Methods

Field collections

Samples were collected under various studies and by various methods: some by hand, some by water sampler, some in conjunction with sediment or pompom samples, some from small vessels, and others from shore. All were 1 liter samples, shipped refrigerated to the analytical lab.

Analytical Laboratory Methods

Laboratory methods and analyte lists are summarized in Payne and Driskell (2015a and 2015b). Briefly, laboratory analyses comprised TPH and selected alkane quantification by GC/ FID (method 8015), and PAH, alkylated PAH, petroleum biomarkers and dispersant indicators by GC/MS SIM (modified method 8270). Initially, all early and pre-oil-impact water samples were shipped to and analyzed at B&B TDI Laboratory but later samples (the bulk of this review) were processed and analyzed at Alpha Analytical Laboratory. Both labs performed in accordance with the DWHNRDA Analytical Quality Assurance Plan (AQAP) (NOAA 2014).

All chemistry data have been validated by EcoChem, Inc. as third-party validators; any results not meeting requirements were qualified during data validation. By forensics preference, the data issued by the lab are used as initially reported, i.e., lab qualified but not surrogate-recovery corrected, below-method-detection-limit results are not adjusted to reporting limits, and non-detects report as zero concentrations. A confirming crosscheck has been made between the lab-issued forensic data and the final EcoChem-validated data (converted back to non-surrogate-corrected status) to ensure data integrity.

Fingerprinting

Method

Fingerprinting nearshore waters initially used the same methods that were used for offshore water forensics (Payne and Driskell, 2015b) employing a mixing-model with DWH weathering-series references, and diagnostic ratios; however, these phase-parsing/hopane-balance techniques were not effective. Most PAH-laden nearshore water samples had either dissolved- or indeterminate-phase profiles (lacking hopane). But dissolved oil PAH only represent a source's partial profile and could potentially derive from other generally indistinguishable background sources, so dissolved PAH alone cannot be directly linked to a source based solely on the sample's hydrocarbon profile. Forensic calls on dissolved-phase samples must instead rely heavily on the secondary confirming evidence that for DWH, mainly involved close proximity to already confirmed, MC252-matching samples from prior forensic evaluations of other matrices (sediments, stranded oil, and tar balls). Fortunately, the overlapping results from Stranded Tarballs, Nearshore, Submerged Oil, and MESSh workplans plus SCAT shoreline-oiling observations provided a reasonably complete spatial pattern of confirmed MC252 matches. Confidence in using these other studies' matches was bolstered by knowing they had had the benefit of complete, particulate whole-oil signatures and confirming biomarkers to establish their matching calls. For nearshore water forensics, the nearby or frequently co-occurring matches or oiled shorelines, elevated TPAH42, and the presence of Corexit indicators (glycol ethers or 2-butoxyethanol) were considered sufficient evidence to justify a MC252 match call. White, et al., (2014) have documented the transport and long-term persistence of dispersants in stranded MC252 oil along the northern Gulf of Mexico shoreline.

As detailed in the offshore waters forensic fingerprinting methods chapter (Payne and Driskell, 2015b), to assimilate the multiple lines of evidence, a proprietary Excel dashboard utility was developed that brings together, for two samples, all relevant data into a single display of multiple graphics and diagnostic values, while superimposing the lab method blank or an appropriate reference sample scaled for comparison (as in Figure 1). The data are retrieved ad hoc from a lab results data table (non-surrogate corrected) within the application, diagnostic ratios are calculated, and results plotted in the interactive displays. For nearshore waters, the distances to nearest matching samples were retrieved into a secondary data table, and made exportable as a layer into Google Earth for spatial perspectives against layers of other water samples, tarballs, sediment matches and SCAT shoreline oiling (Figure 2). On rare occasions, photos or field notes were retrieved from NOAA NRDA file collections to further understand particular sampling conditions or methods.

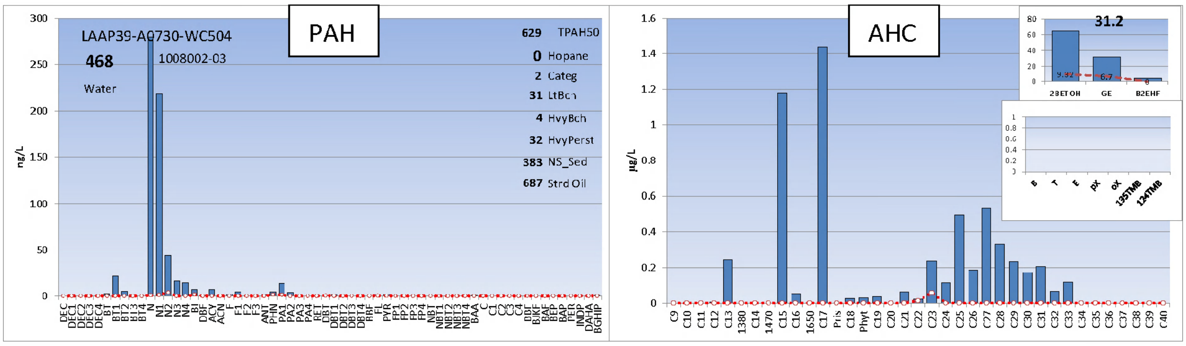


Figure 1. Example of a strong dissolved-phase, nearshore water sample showing PAH (left), AHC (right), dispersant indicators and BTEX (upper right). Text in PAH plot (left) tabulates TPAH, hopane, and distances to nearest matching nearshore sample of various data matrices. Red reference line is method blanks for each analyte.

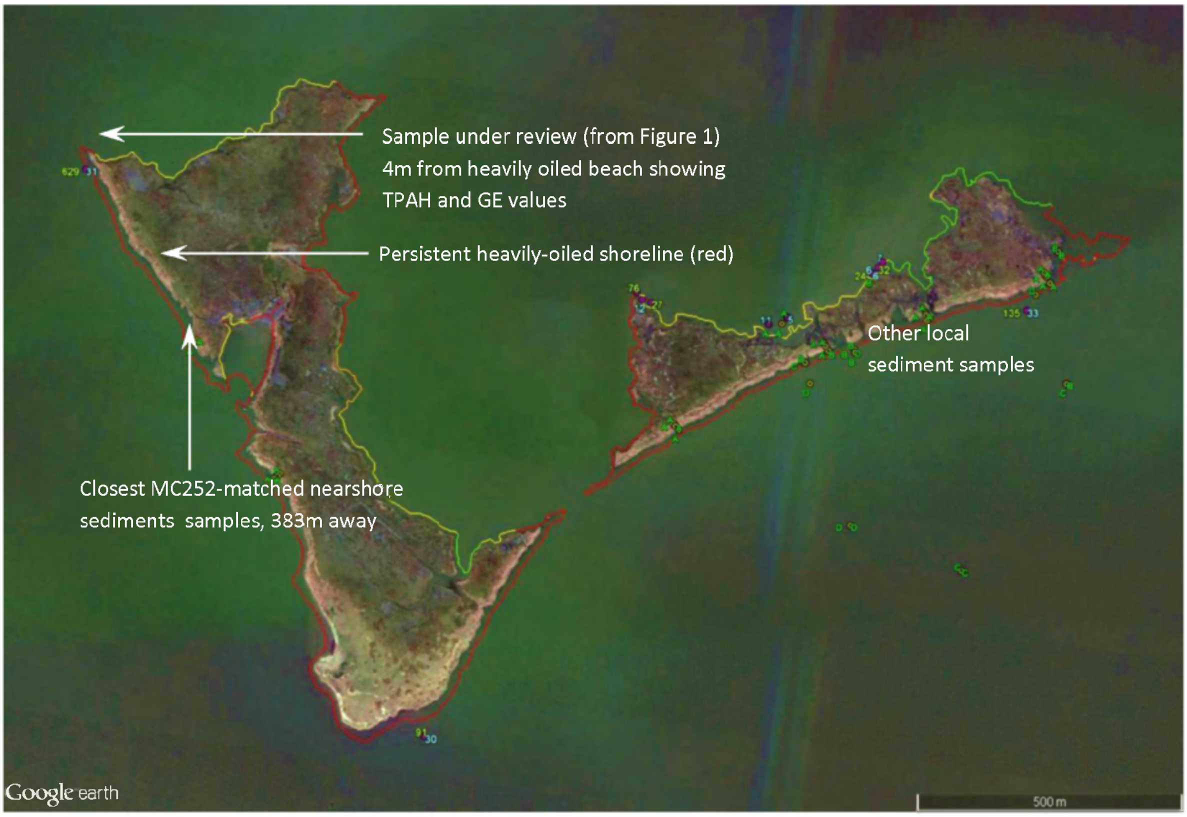


Figure 2. Example of contextual spatial information used in forensic assessment. Small numbers show TPAH42 and glycol ethers (GE) values. Locations with A or B had MC252 matched sediments.

Matching Categories

In establishing exposure to oil, traditional ASTM methods use match, indeterminate, or no-match categories to describe forensic results. For DWH water samples, a similar approach is used; however, for further understanding the oil's behavior and supporting modelling needs, the positive-matched category is further subdivided into phase assignments, i.e., particulate, dissolved or indeterminate phased. For reporting NRDA forensic water samples, seven categories have become relevant to the case (Table 1). The first three categories are considered positive matches (consistent with MC-252 oil) that are only differentiated by phase profiles. The remaining four are either "other" oil, inconclusive, or clean.

Table 1. Forensic Matching Categories for Water Samples

	Category Code	Comparable Category*	Description
Match	1	A	MC252—containing particulate phase (with or without extra dissolved)
	2		MC252—dissolved phase only
	3		MC252— phase uncertain, (irresolvably complex)
No Match	4	E	other oil or obvious ship-board contaminants (e.g., hydraulic fluid)
Indeterminate or clean	5	C	possible MC252 – oil-like profile but insufficient to link to MC252
	6	D	indeterminate—trace PAH detected but no oil-like profile
	7		no PAH detected or apparent noise (clean)

*Categories used in other reports on DWH forensics assessments of oil, tissues and sediment matrices.

Exposure

Using a hopane-balance method developed for offshore water forensics, it was apparent that the few particulate-phase matches contained a mixed profile with excess hopane in a higher ratio to TPAH than was available in the source oil (Figure 3). Hopane is considered to be a conserved, weather-resistant, biomarker compound, such that surplus hopane would suggest another highly weathered source is bringing additional hopane without contributing any substantial amount of PAH (Figure 4). Logical sources are oiled sediments, residual from the initial stranding or washed from the oiled shoreline and likely re-suspended by sampling operations or some other local turbulence event. Thus, all 21 of the Category 1 samples are considered to be weathered MC252 matches but from post-stranding events.

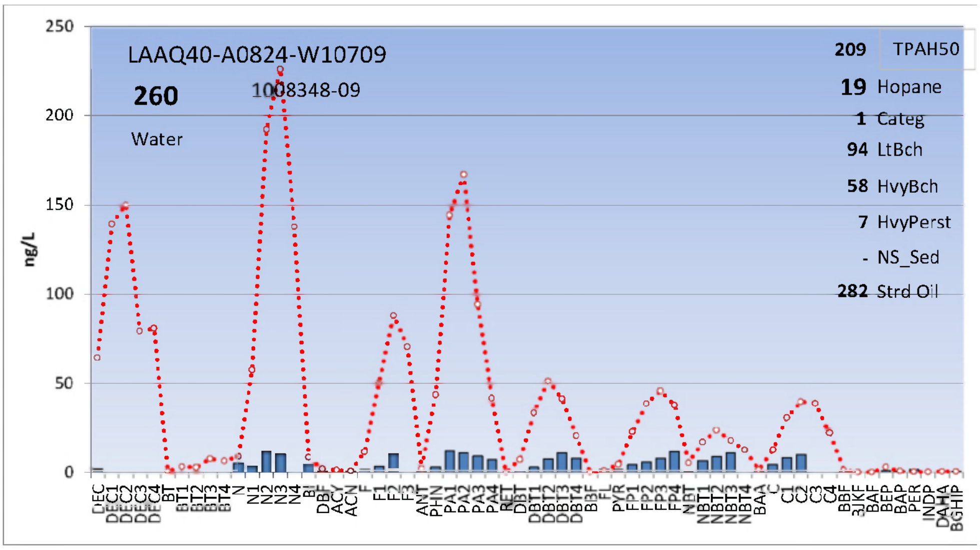


Figure 3. Example of category 1, MC252-matched water sample PAH fitted with MC252 source oil (red line) by scaling reference-oil hopane to sample hopane. Differences (gaps) between sample and reference line suggests sample weathering; however, the resistant NBT and C groups should not be appreciably weathered. These patterns instead suggest excess hopane in the sample most likely contributed from re-suspended, heavily weathered, oiled sediments.

Box-and-whisker plots of the three matching categories (Figure 5) show the low TPAH42 distributions (ppt) and demonstrate that the particulate oils tend to occur in higher TPAH42 concentrations than the dissolved and indeterminate-phase samples. Cumulative distributions of distance to nearest matched sample (other studies, all matrices) confirms that 48% of the category 1, matched water samples were located less than 10 m from a nearby match, and 87% were within 100 m to nearby, non-water, matched samples (Figure 6).

As mentioned above, the dissolved-phase or Category 2 samples cannot be assigned to a source based solely on their hydrocarbon signatures. Unlike the solid matrices (sediments, tissues and oils), there are no biomarkers to confirm their source. Category 3 samples are designated "phase uncertain" implying only that their phase assignment (dissolved vs. particulate/oil) was uncertain; these are considered MC252 matches equal in confidence with the other two matches. For both Categories 2 and 3, the secondary data, i.e., nearest matches from other matrices, oiling observations, and dispersant indicators, are used to establish linkage to MC252 (Figure 7 and Figure 8). Note that for all three matching categories, the samples tend to cluster in their spatial regions amongst themselves and obviously associated with the supporting data from stranded oil matches, sediment matches and SCAT reports (Figure 9, Figure 10, Figure 11, Figure 12 and Figure 13).

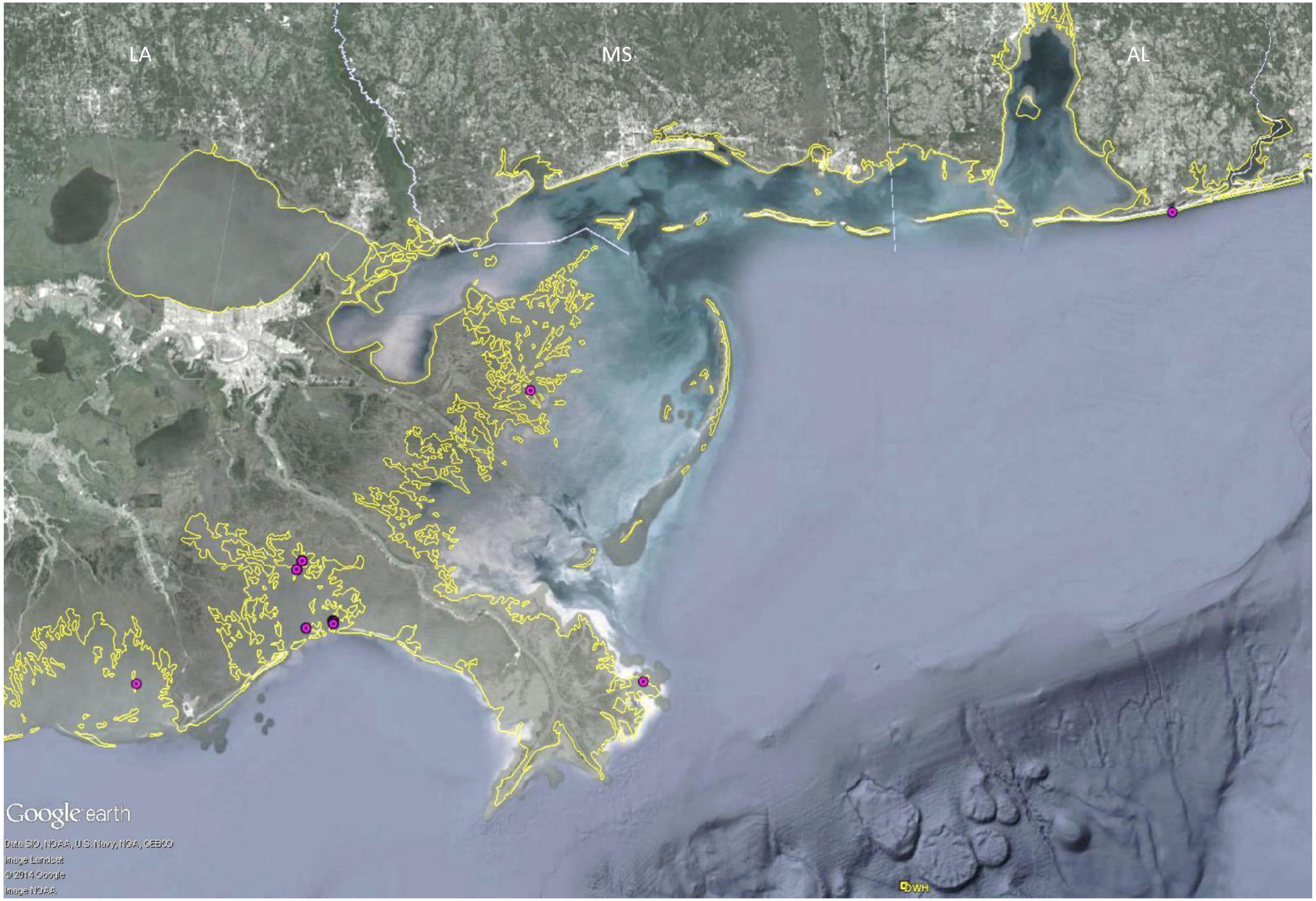


Figure 4. Locations of category 1, particulate-phase MC252 matches (n=21). Most samples contain excess hopane, suggesting association with weathered, oiled re-suspended sediments rather than free oil droplets. Coastline in yellow.

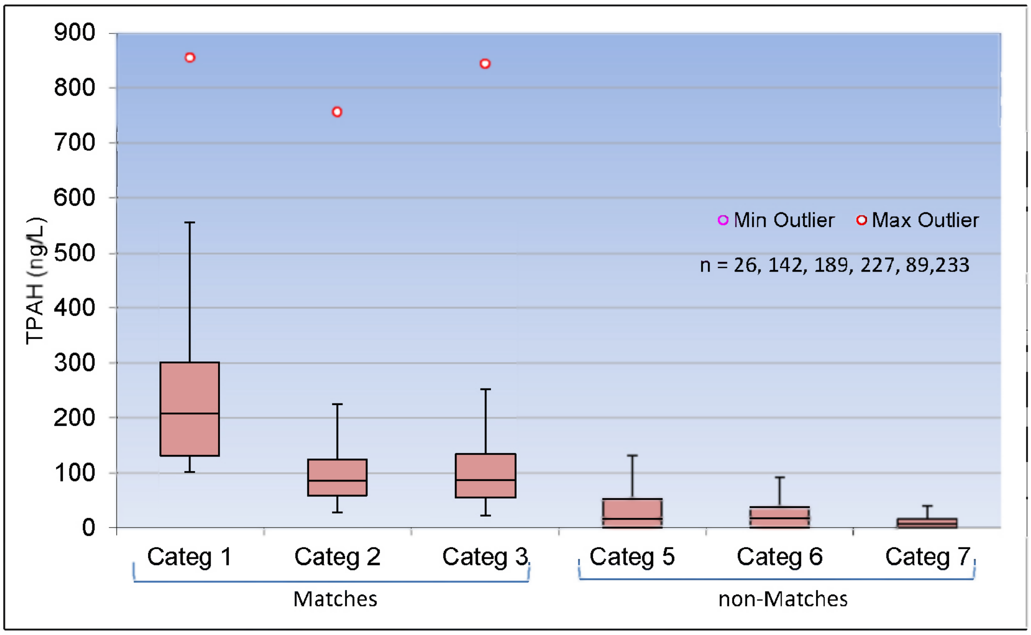


Figure 5. Box-and-whisker plots of TPAH42 (ng/L, ppt) distributions of matched samples by phase categories. Box shows median with 2nd and 3rd quartiles plus whiskers showing max and min or if outliers are present, showing 1.5 x quartile range. Both Cat 2 and 3 have extreme outliers in 1,600 ng/L range that are not displayed.

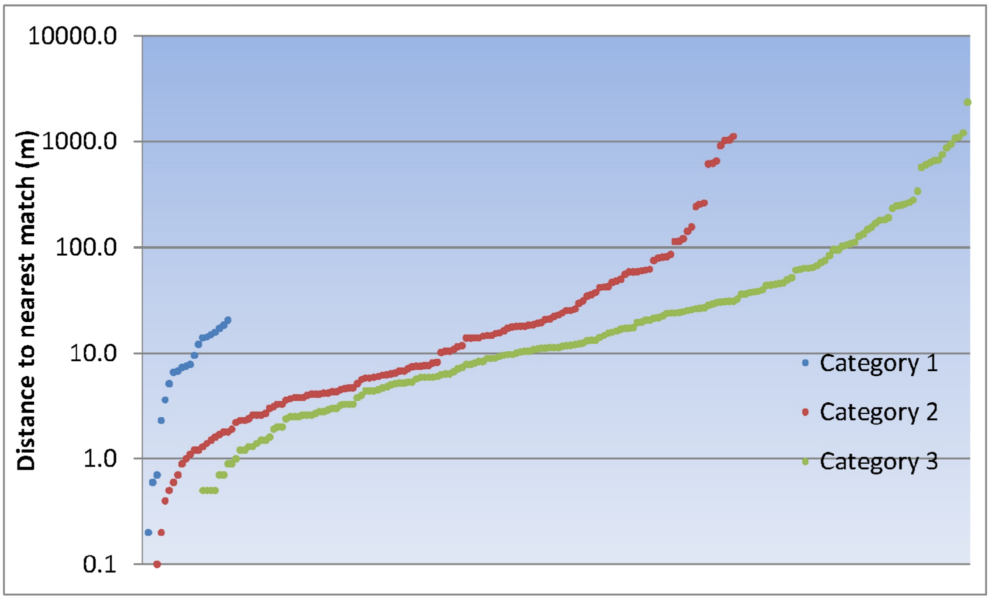


Figure 6. Distributions of distance to nearest matched sample by phase category

The non-matching categories' patterns (Figure 14) demonstrate that there were locations within the spill region that either did not show significant hydrocarbon signal or that were clearly not from the DWHOS.

Time series of forensically matched samples logically demonstrates a high frequency of confirmed samples early in the spill and then tapering off to no matches by the end of 2010 (Figure 15). Compiled SAR images on NOAA's Emergency Response Management Application (ERMA) show the temporal stranding events (Figure 16), information relevant for corroborating forensic assessments.

Oil behavior in nearshore versus offshore

In the offshore, all water samples containing forensically matched, particulate-oil droplets were attributable to plumes or surface slicks. In contrast, nearshore water samples containing particulate oil droplets were rare. Profiles of the few samples reported with particulate oil contained weathered patterns with *excess* hopane, which suggested a component of suspended sediments from some recent disturbance event (e.g., storm or sampling) rather than nominally weathered, slick-associated oil.

The preponderance of nearshore samples comprised dissolved- and mixed-phase matches, which suggests one or two different scenarios. Presuming that transiting slicks or sheens would have an associated near-surface component of oil, then depending on when and how water samples were taken (proximity to surface) and recent turbulence events, the samples might contain both dissolved oil and small droplets. But the reviewed data mostly don't show two phase components; of 340 dissolved and mixed phase forensically matched samples (Categories 2 and 3), only 41 contained low-level hopane indicative of particulate hydrocarbons. These 41, all sampled between Aug-Oct 2010, had a mostly dissolved-phase pattern with their hopane attributed to a trace of suspended sediments. Some portion of the 51 forensic matches from July and 91 from August 2010, based solely on their sampling dates, may have contained undocumented floating-slick-related dissolved components. However, the additional 194 forensic hits collected between Sept-Dec 2010, when surface slicks were no longer present, suggests only one scenario; the predominantly dissolved-phase profiles derive from the backwash or leaching dissolution components from stranded oil or submerged mats.

Table 2. Summary of forensically matched nearshore water samples from various sampling periods. Categories described in Table 1.

Matched	July	August	Sept-Dec	all dates		with hopane
Category 1	1	18	2	21		21
Category 2	20	39	82	142		0
Category 3	31	52	112	198		41
Total	52	109	196	361		62

Passive sampling devices were also used in assessing impact of Macondo oil-derived PAHs in nearshore waters (Allan et al. 2012). This study had shown an increase in the dissolved PAH in nearshore water in 2010 following shoreline oiling, with concentrations returning to pre-spill conditions by March 2011. Similar stranded-oil leaching and contamination of interstitial water from the more protected intertidal habitats in Prince William Sound was documented 13 years after the *Exxon Valdez* oil spill (Payne, et al., 2005).

In summary, from the July and August samples, the dissolved phase components could derive either from stranded oils or passing floating oil (undocumented in this study). From the later samples (Sept-Dec), the dissolved components are most likely coming from previously stranded oils or submerged mats.

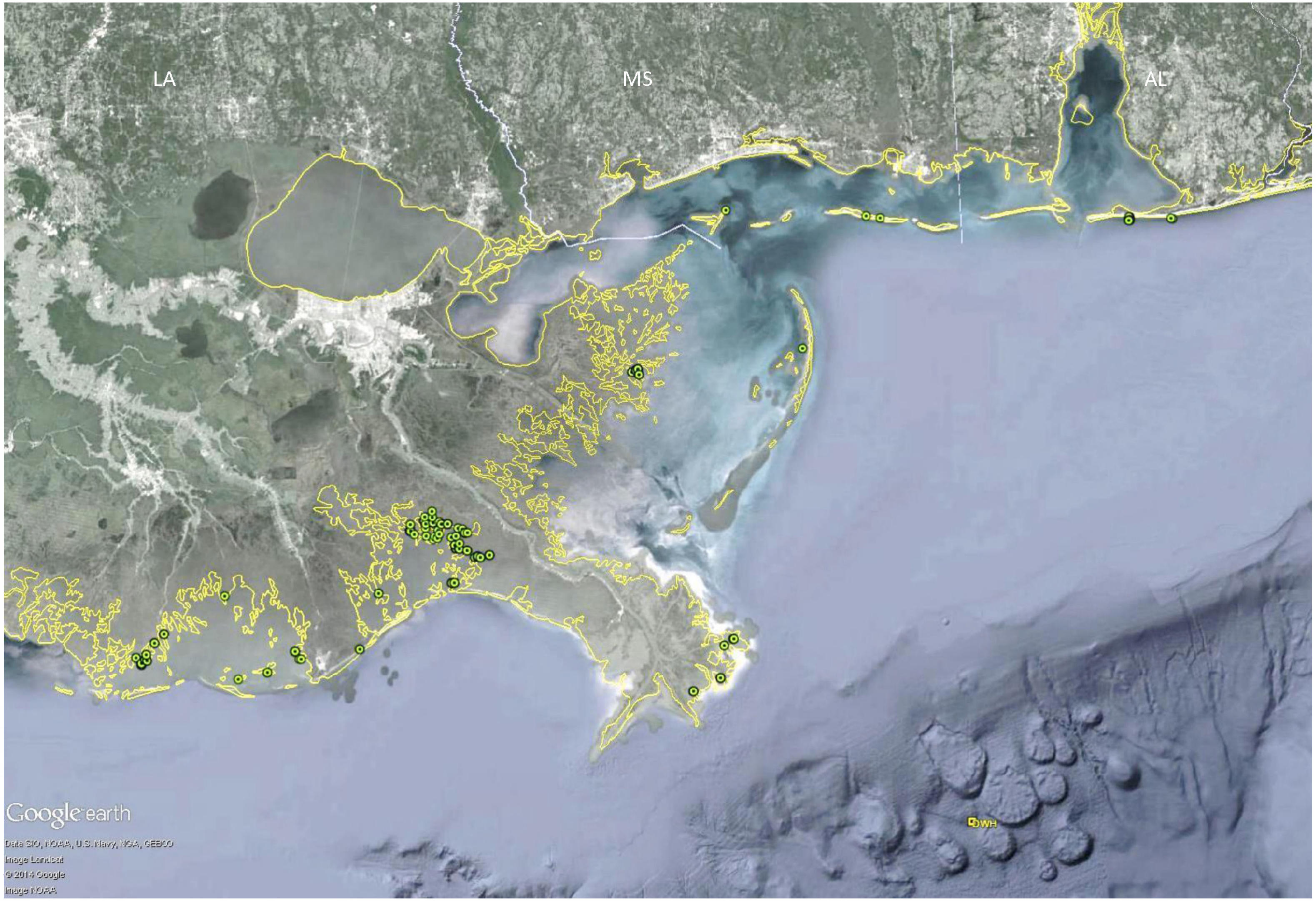


Figure 7. Locations of category 2, dissolved-phase MC252 matches (n=142). Coastline in yellow.

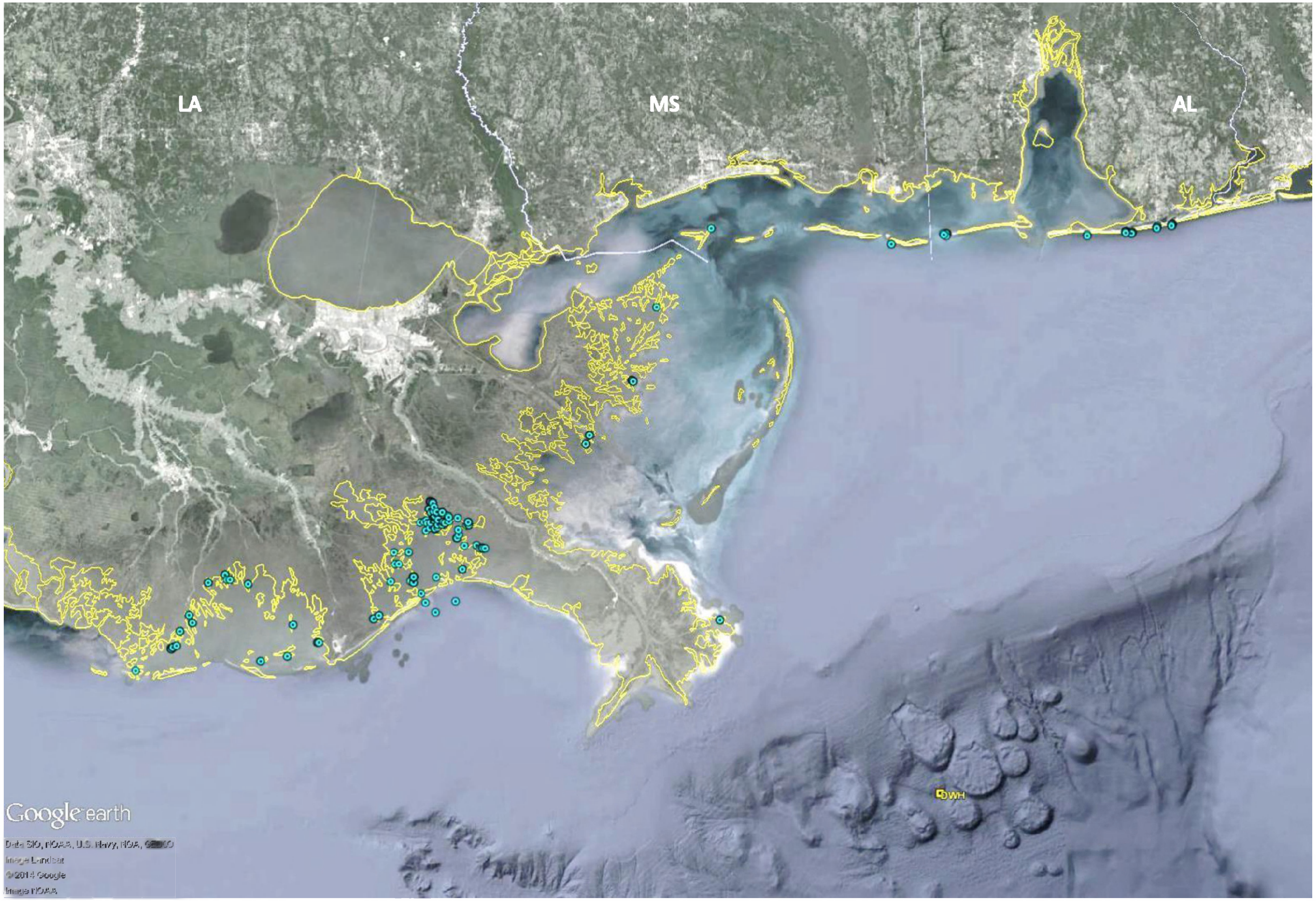


Figure 8. Locations of category 3, uncertain, indeterminate-phase MC252 matches (n=198). Coastline in yellow.

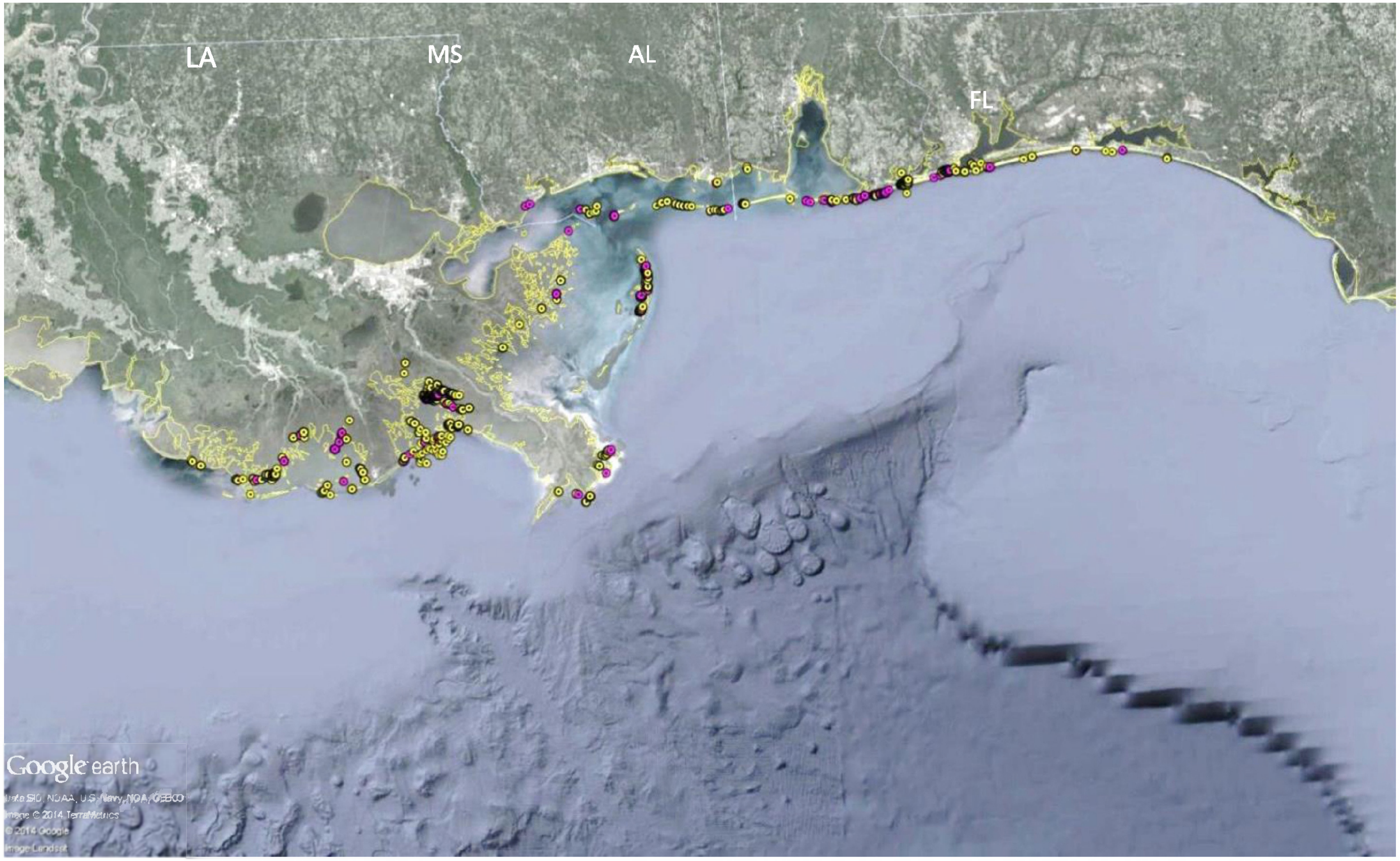


Figure 9. Locations of MC252-matched nearshore sediment samples. Category A matches in red (n=423), category B matches in yellow (n=872). Data from Emsbo-Mattingly, 2015.

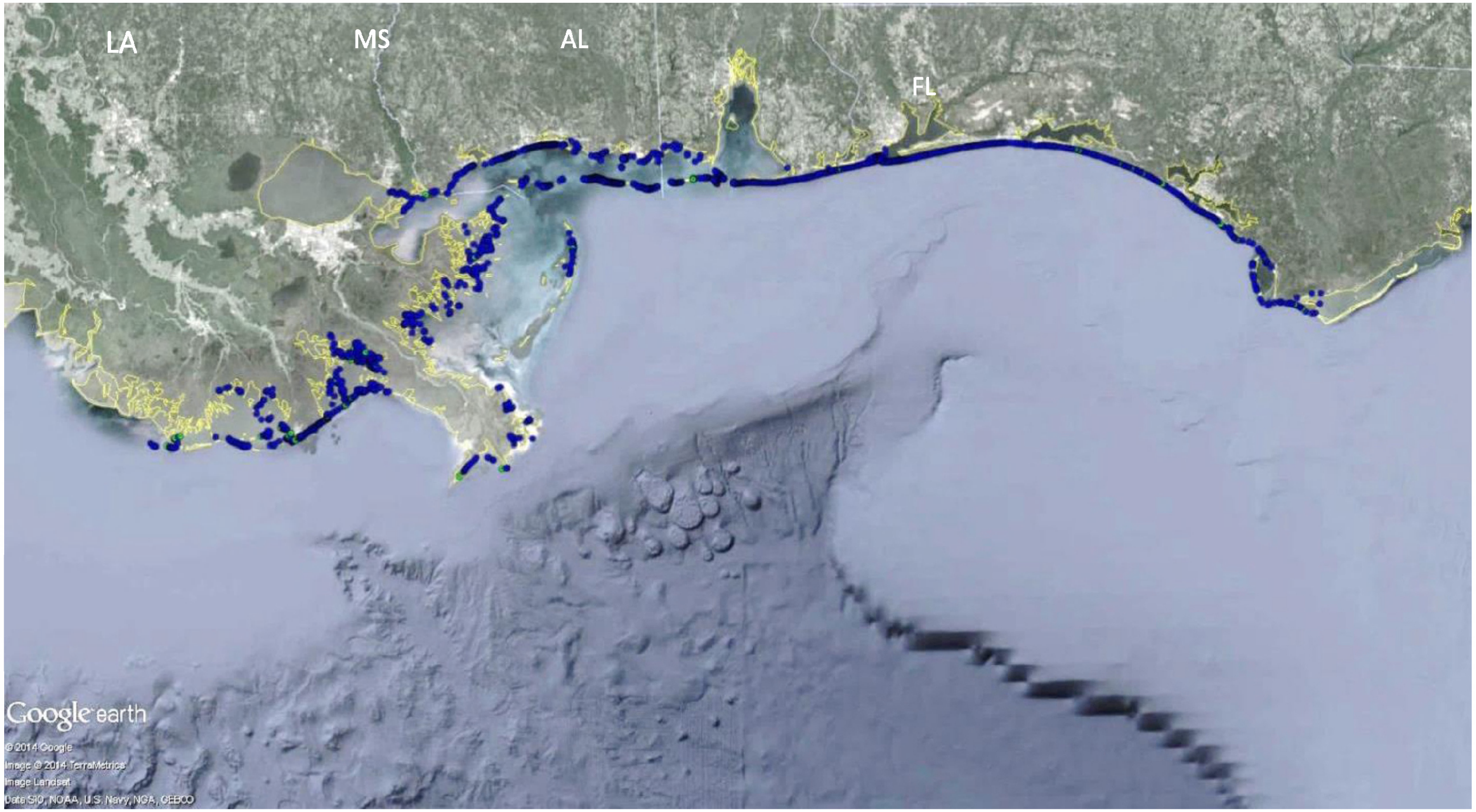
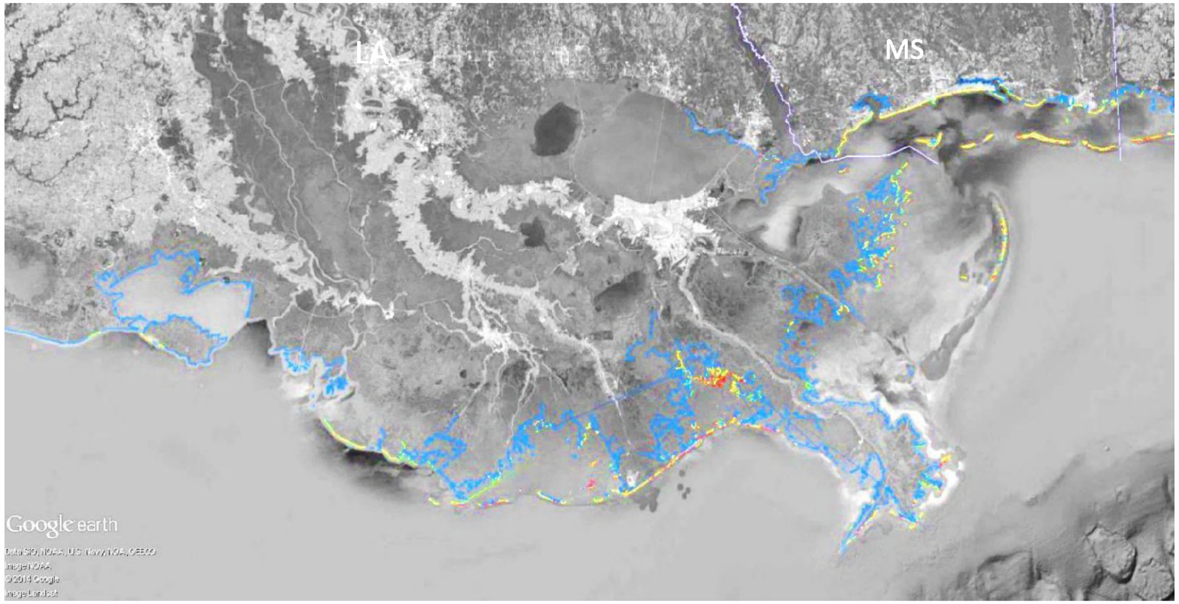


Figure 10. Locations of MC252-matched stranded oil samples (data from Stout, 2015).



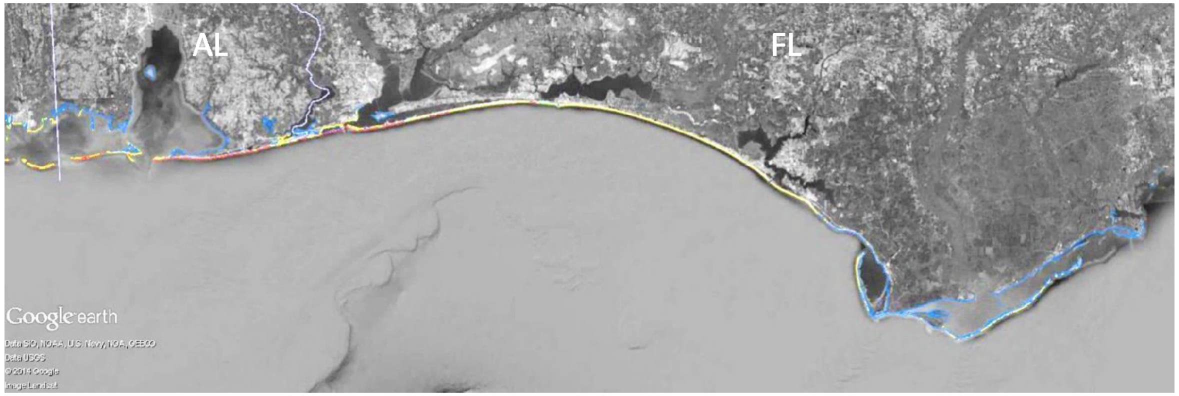


Figure 11. Shoreline oiling observations (SCAT surveys).Colors scaling from blue to red indicate increasing severity of stranded oiling from no oiling to heavy persistent oiling. Data from NOAA's Environmental Response Management Application (ERMA).

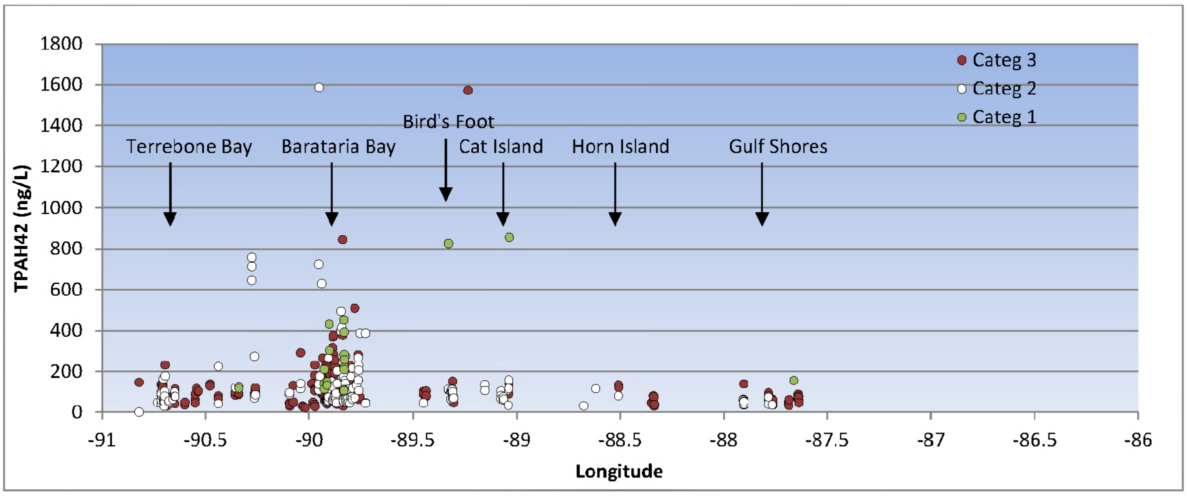


Figure 12. Longitudinal series of MC252-matched water samples' TPAH42 showing clustered distributions and loadings.

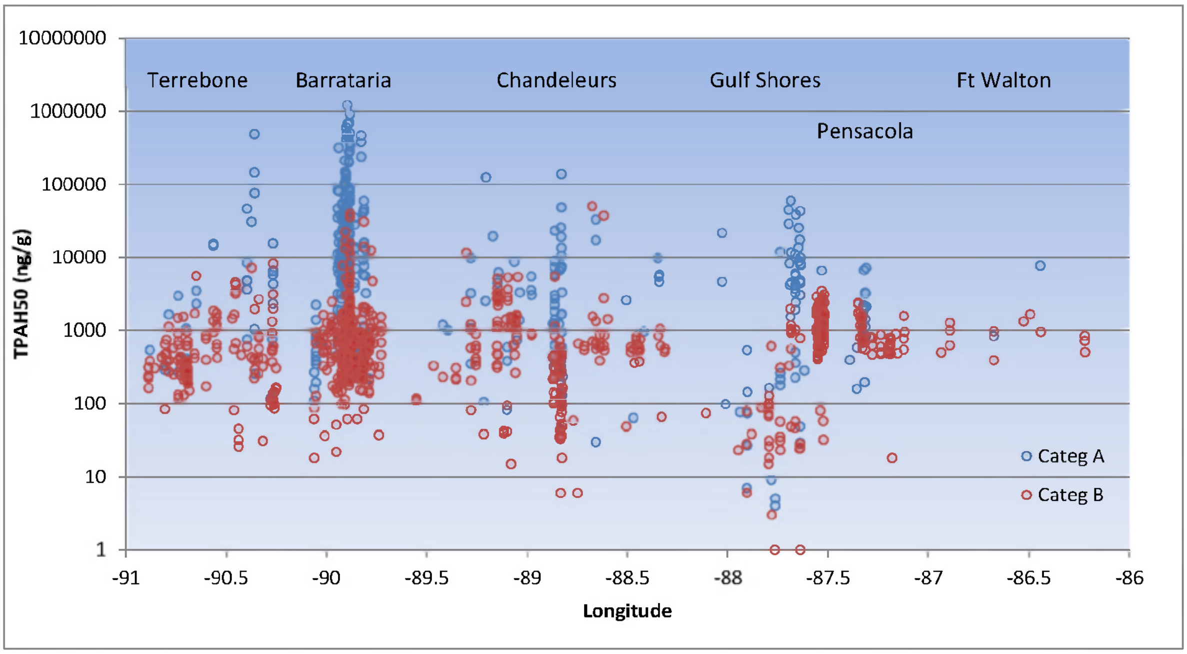


Figure 13. Longitudinal series of MC252-matched nearshore sediments' TPAH50 showing clustered distributions and loadings similar to waters (Figure 12). Sediment categories A and B are MC252 match and probable match, respectively (data provided by Emsbo-Mattingly, 2015).

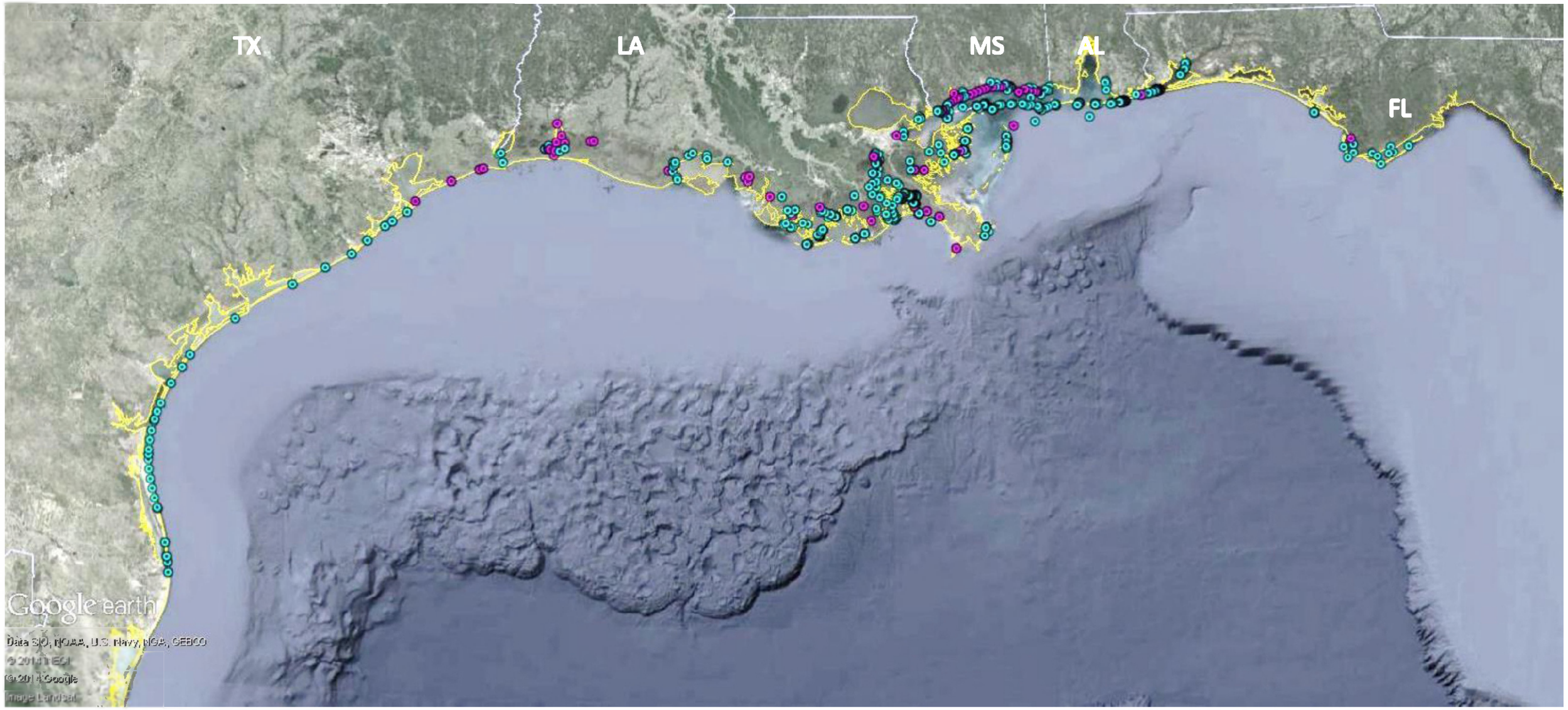


Figure 14. Locations of nearshore waters non-matching categories 4, 5, 6 and 7. Other oils (Category 4, red, n=85) and indeterminate or clean samples (Category 5-7, blue, n=585). Coastline in yellow.

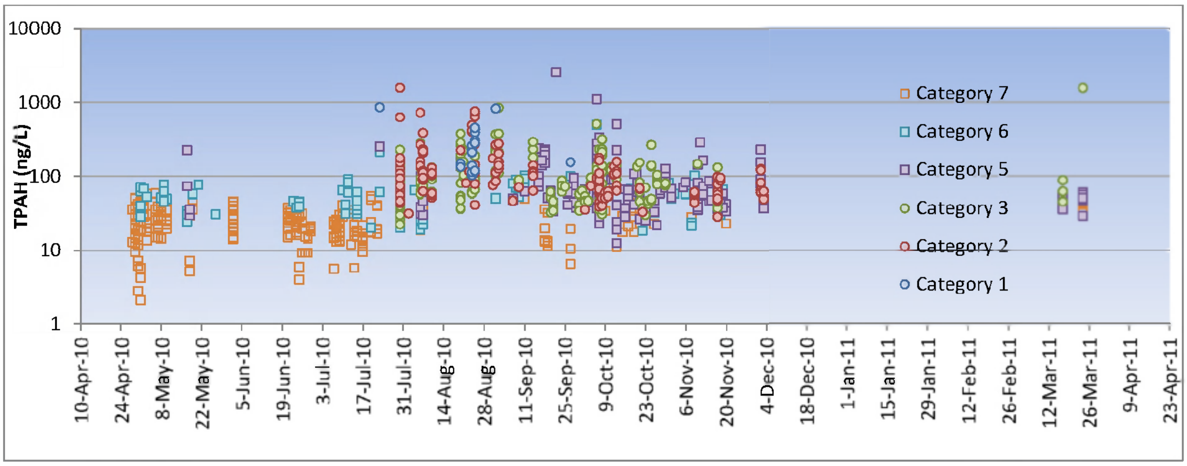


Figure 15. Time series of nearshore NRDA water samples. Categories 1-3 are matches to MC252 oil.

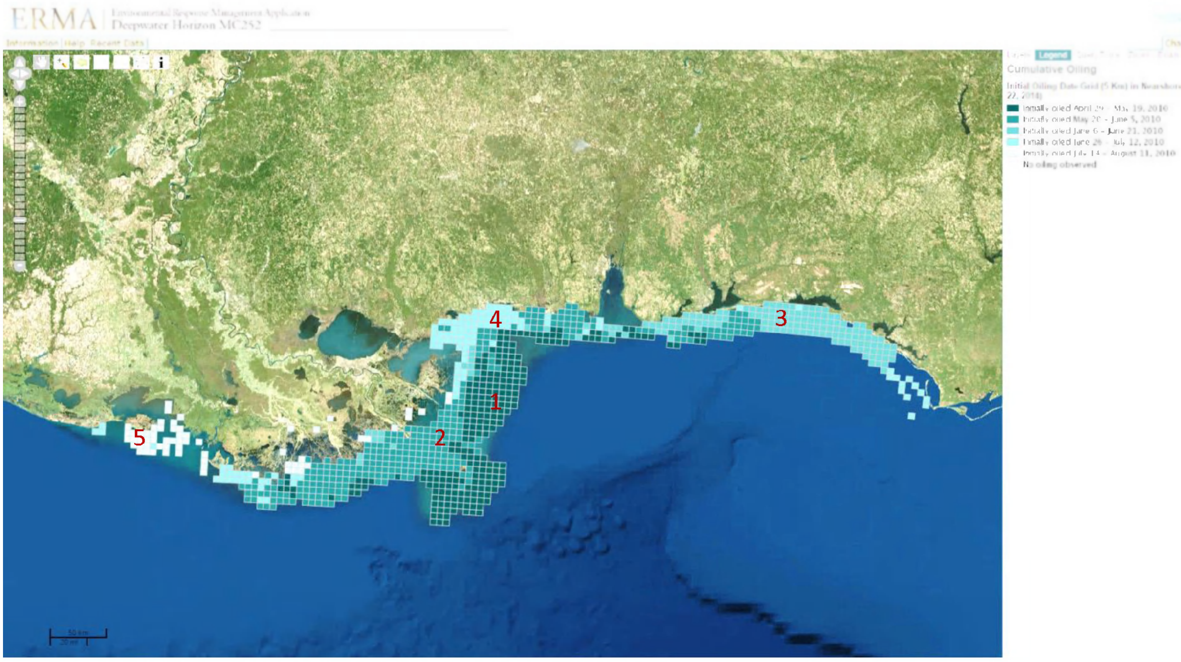


Figure 16. Time series of initial oiling (from ERMA layer). Colors indicate timing of oil coverage: 1) 29 Apr-19 May, 2) 20 May-5 June, 3) 6 June-21 June, 4) 26 June-12 July, 5) 14 July-11Aug.

Table 3. Counts of nearshore water sample forensic categories by study and workplan.

		Match			Other Oil	Non-match			
Workplan	**Study Name**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**Total**
25 Foot Parker UV Cruise 01 OCT 25-26 2010	25 Foot Parker UV Cruise 01 OCT 25-26 2010			5		2	1	1	**9**
Fish--Preassessment-Fish Kill--2010	Fish--Preassessment-Fish Kill--2010		2			10			**12**
Fish--Preassessment-Submerged Oil Characterization--2010	Fish--Preassessment-Submerged Oil Cha--2010	1	11	35	2	89	19	28	**185**
Fish--Preassessment-Submerged Oil Colllections--2010	Fish--Preassessment-Submerged Oil Col--2010				6		1	5	**12**
Nearshore Sed & Water--Preassessment-Late JUL 2010	Nearshore Sed & Water--Preassessment-Late JUL 2010	1	20	31		6	1	3	**62**
Nearshore Sed & Water-Preassessment-Early AUG 2010	Nearshore Sed & Water-Preassessment-Early AUG 2010		22	21		8	6	6	**63**
Nearshore Sed & Water--Preassessment-Late AUG 2010	Nearshore Sed & Water--Preassessment-Late AUG 2010	18	15	30		3			**66**
Nearshore Sed & Water--Preassessment-Early SEP 2010	Nearshore Sed & Water--Preassessment-Early SEP 2010	1	19	28	1	2			**51**
Nearshore Sed & Water--Preassessment-Late SEP 2010	Nearshore Sed & Water--Preassessment-Late SEP 2010					3			**3**
Nearshore Sed & Water--Preassessment-Early OCT 2010	Nearshore Sed & Water--Preassessment-Early OCT 2010		23	24		36	1		**84**
Nearshore Sed & Water--Preassessment-Late OCT 2010	Nearshore Sed & Water--Preassessment-Late OCT 2010		2	13	1	11	6	3	**36**
Nearshore Sed & Water--Preassessment-Early NOV 2010	Nearshore Sed & Water--Preassessment-Early NOV 2010		6	1		22	1		**30**
Nearshore Sed & Water--Preassessment-Late NOV 2010	Nearshore Sed & Water--Preassessment-Late NOV 2010		11	6		7			**24**
Nearshore Sed & Water--Preassessment-Early DEC2010	Nearshore Sed & Water--Preassessment-Early DEC2010		8			10			**18**
Nearshore Sed & Water--Preassessment-2011	Nearshore Sed & Water--Preassessment-2011			4		11		3	**18**
Nearshore Sediment and Water Baseline Sampling for Louisiana	Nearshore Sed & Water--Baseline--Early JUL 2010				7		2	22	**31**
	Nearshore Sed & Water--Baseline--Late JUL 2010				4				**4**
	Nearshore Sed & Water--Baseline--Late JUN 2010				7		4	35	**46**
No Formal Workplan/TBD	Fish--Baseline Commercial Oyster Beds 2010				8				**8**
Not Defined	AL DCNR--Preassessment--Early MAY 2010							4	**4**
	FLDEP--Baseline--Early MAY 2010				2		3	22	**27**
	FLDEP--Baseline--Late MAY 2010				1		1		**2**
	FL-FWC--MAY 2010							4	**4**
	MDEQ Preassessment Early MAY 2010				17		6	23	**46**
	MDEQ--Preassessment--Late APR 2010				12			14	**26**
	NPS--Gulf Islands National Seashore 2010				2	4	7	7	**20**
	NPS--Padre Island National Seashore 2010							12	**12**
NPS--Jean Lafitte National Historical Park 2010	NPS--Jean Lafitte National Historical Park 2010				1		2		**3**
Oyster--Preassessment-OysterSampling--2010	Oyster--Preassessment-OysterSampling--2010							5	**5**
SAV - Tier 1 Workplan	SAV--Baseline-Tier1--2010							12	**12**
SAV--Jean LaFitte--2010	SAV--Jean LaFitte--2010				2		6		**8**
SAV--Preassessment tier 2--Early AUG 2010	SAV--Preassessment tier 2--Early AUG 2010		1			2	1	1	**5**
SAV--Preassessment tier 2--Late AUG 2010	SAV--Preassessment tier 2--Late AUG 2010		2						**2**
SAV--Preassessment tier 2--Early SEP 2010	SAV--Preassessment tier 2--Early SEP 2010					1	3	1	**5**
Shoreline-Preassessment-Rapid Marsh Oil--2010	Shoreline-Preassessment-Rapid Marsh Oil--2010				2				**2**
Shoreline-Texas Baseline--2010	Shoreline-Texas Baseline--2010							10	**10**
Swift Energy Oil Spill Feb 2013	Swift Energy Oil Spill Feb 2013				2				**2**

TX Baseline	Shoreline-Texas Baseline--2010				8		14	12	**34**
Total		**21**	**142**	**198**	**85**	**227**	**85**	**233**	**991**

Appendix 1 BP Nearshore Water Sampling (NGOM)

BP's independent Nearshore Gulf of Mexico (NGOM) water-sampling study (study reference number, SRN 37.2) was initially considered relevant to this report. The study comprised 2,908 samples taken in repeating (near) weekly intervals at fixed stations at 5 mile intervals in open waters across coastal Gulf of Mexico.

From BP documents, the objectives of the Work Plan were as follows:

- Document surface water hydrocarbon concentrations in nearshore habitats after the projected landfall of spill-related hydrocarbons
- Document subtidal sediment hydrocarbon concentrations and grain size conditions in nearshore habitats after the projected landfall of spill-related hydrocarbons.

  The Work Plan was developed to document potential changes in nearshore areas at high risk for exposure to oil. The geographic scope of the Nearshore Water and Sediment study consisted of the Gulf of Mexico (Gulf) coastline from the Texas/Louisiana border to Apalachee Bay, Florida. Sampling was conducted at transects at 5-mile intervals between transects used in the Shallow Subtidal Baseline study (Study Reference No. 37.1). This program expanded on the Shallow Subtidal Baseline Plan sampling design by collecting surface water and sediment samples at the Shallow Subtidal Baseline Plan sampling stations, adding sampling stations between the original stations to provide higher geographic resolution in the collected data, and replicating the sample collection location across several sampling periods resulting in a time-series dataset. The study consisted of the collection of water and sediment samples for chemical analysis.

This forensic assessment only addresses the water samples. Implementing the same methodology as used for the NOAA NRDA cooperative nearshore water data, NewFields was asked to augment the data with nearest matched samples of sediments, tarballs, pom poms and SCAT categorized shorelines.

Synopsis

From this 6 month program, 2,908 samples were analyzed by Columbia Analytical Services (CAS) from mostly weekly visits to 152 stations (Figure 17). Except for nine samples off Gulf Shores, Alabama, in June-July 2010, there were no other identifiable MC252 matches (Figure 18, Table 4). The nine matching samples included: 6 weathered particulates, 1 dissolved and 2 unparseable-phase samples (categories 1, 2 & 3, respectively). TPAH50 ranged from 25 to 2,613 ppt (Table 5).

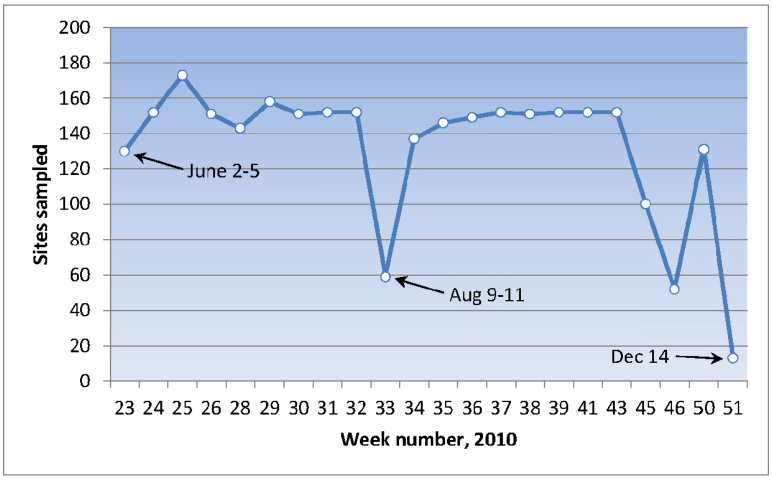


Figure 17. Weekly sampling frequency for BP's NGOM, 2010.

Table 4. Summary of forensic assessments for NGOM, 2010.

Forensic category	1	2	3	4	4b	5	6	7	Total
NGOM	6	1	2	32	50	45	141	2630	2908

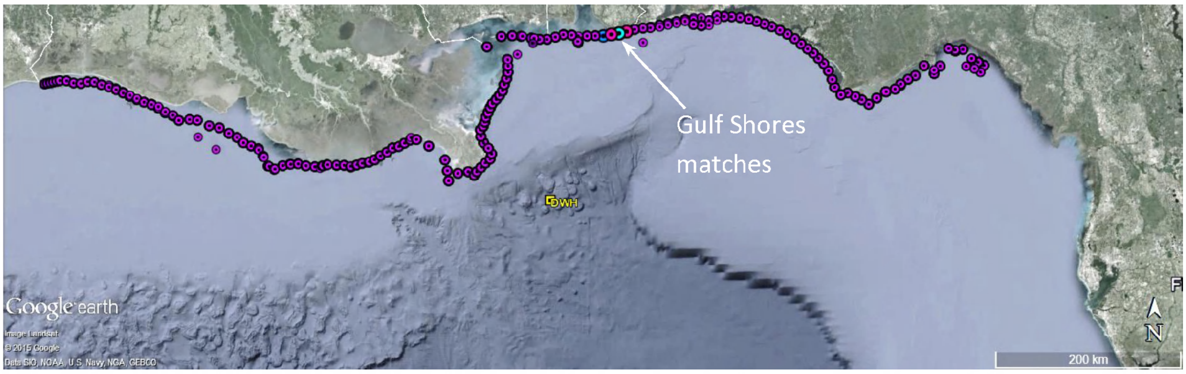


Figure 18. BP NGOM samples (n=2,908). Nine samples from Gulf Shores in June-July 2010 were forensically matched to MC252.

Table 5. Summary of TPAH50 for MC252 matched samples

Category	avg TPAH (ppt)	Min	Max	Count
1	996	416	2613	6
2	606	606	606	1
3	27	25	29	2

Another fifty samples showed a lab interference pattern (tagged as category 4b) with NBTs greater than DBTs and often an unnatural DBT3 spike (Figure 19). With a mean of 29,210 ppt, these samples should not be considered as part of the typical contaminated background. Furthermore, if they even partially represented a regional background source, their wide-spread occurrence across the Gulf shoreline would not be expected (Figure 20); i.e., confirming this looks more like a lab artifact than a recurring background profile. Other profile characteristics (TPH), suggested that 47 of the 50 samples could, ignoring the anomalies, represent some form of weathered oil. But in delving further, additional confounding issues with lab method blanks implied these data would have to be evaluated on a sample by sample basis *after* the lab issue had been understood. Since none of the samples were going to be relevant as MC252 matches, it was decided to collectively annotate them as "other oil with lab issues," and assigned them to category 4b. There were, however, 32 samples without obvious lab issues contained "other oil" that suggest background oils do occur along the Gulf shoreline.

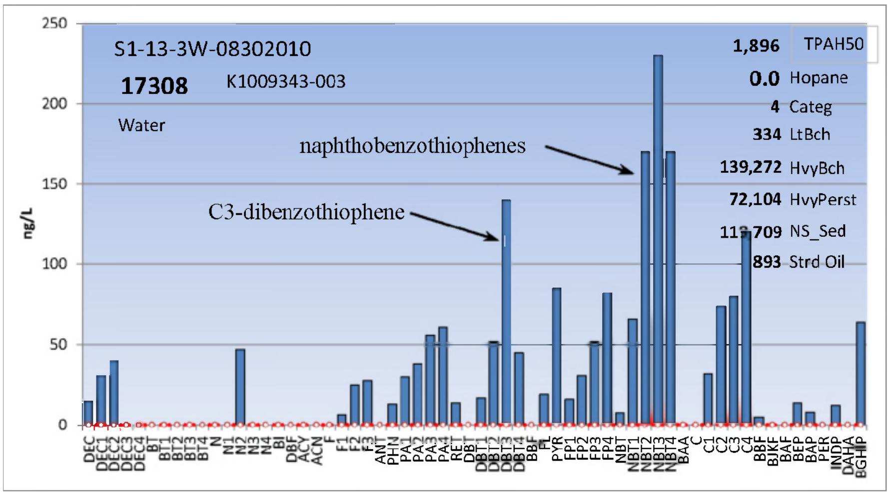


Figure 19. Suspected lab interference pattern showing unnaturally high naphthobenzothiophenes (NBTs) and a DBT3 spike (n=53).

Figure 20. Distribution of samples with suspected lab interference.

Discussion

The NGOM program was an intensive sampling program collecting at fixed 5 mile interval locations in a weekly time series fashion across the nearshore Gulf. The program was commendable in its efforts but suffered from two aspects: 1) documenting whether sampling occurred when/where oil was visibly present and 2) lab issues confounded some results.

During our forensic evaluations, observational data were not available to confirm presence/absence of oil slicks during sampling. It may be the case that some samples were taken in or near surface oiling but, except for the few samples taken off Gulf Shores (and other than some badly contaminated field and equipment blanks), there was no confirmable matched particulate pattern of oil droplets. Unlike the NRDA nearshore water dataset where secondary evidence of nearby confirmed tarballs, oiled shorelines or bottom sediments was used to support matching an otherwise, unlinkable dissolved phase profile, dissolved-phase NGOM samples from further offshore are lacking any secondary evidence. As such, there is no possibility of confirming MC252-related dissolved phase samples if they did occur (again, except off Gulf Shores). Also, note that the most likely profile collected at the reported sampling depth of 10cm, in presumably mild seas for small vessel operations, would be a dissolved phase profile.

As of July 2015, we have searched available BP files for field notes or logs and have found none in Trustee archives. However, we do see annotations in one photo log suggesting that such documents did exist. In perusing a few field photos, both sheens and tarballs were encountered at sites. Field notes reflecting the presence of oiling would be sufficient secondary evidence to re-evaluate the data for dissolved patterns.

It must also be pointed out that although great effort was put into collecting and analyzing these samples, the design would, at best, only capture an oil profile entrained below a transient, slick-covered, parcel of water. While understanding exposure in this habitat is desirable, it would be of lower impact and thus, lower priority, relative to assessing exposure from oiling permanently stranded on the shoreline and exposing its adjacent waters. By sampling at slightly deeper (more accessible?) stations, these "nearshore" exposures were actually "shallow offshore" measurements where, from passing encounters with slick-entrained hydrocarbons at fixed sites, highly variable results would be expected.

In the 50 samples confounded by lab interferences/QC issues, TPAH50 levels averaged 6,565 ppt, (range 210 to 29,210 ppt) and mostly comprised particulate phase profiles, often with a petrogenic higher-molecular-weight SHC group. The lab obviously measured some type of oil but we're unable to tell the field portion and its source patterns from the lab artifact (the pattern shown in Figure 19 was also observed in field blanks). It is unknown whether these higher TPAH particulate samples were actually related to MC252 slicks.

Appendix 2 Shallow Subtidal Benthic and Water Baseline Plan for MC252 NRDA

The Shallow Subtidal Benthic and Water Baseline Plan for MC 252 NRDA (Work Plan 37.1) was developed as part of the natural resource damage assessment (NRDA) for the Deepwater Horizon (DWH) oil spill. An independent study prepared by representatives of BP Exploration & Production Inc. and BP Gulf Coast Restoration Organization (BP), it was implemented from May 12, 2010 to May 27, 2010.

From BP's documents, the objectives of the Work Plan were to:

- Document surface water hydrocarbon concentrations in nearshore habitats ***prior*** to the projected landfall of spill-related hydrocarbons
- Document subtidal sediment hydrocarbon concentrations and grain size conditions in nearshore habitats prior to the projected landfall of spill-related hydrocarbons
- Document the baseline benthic infauna community prior to landfall of spill-related hydrocarbons.

Study Approach

The Work Plan was developed to establish baseline conditions of surface water and sediment hydrocarbon concentrations and the benthic infauna communities in the shallow subtidal habitats along Gulf of Mexico (Gulf) shorelines from Louisiana to Florida Bay. The geographic scope of the Shallow Subtidal Baseline study consisted of the Gulf coastline from the Texas/Louisiana border to Florida Bay, Florida. Sampling was conducted in three phases. Phase 1 was sampling of transects at 50-mile intervals along the entire geographic area. Phase 2 was also sampling of transects at 50-mile intervals but offset from the Phase 1 transects by 25 miles. Phase 3 was stratified random sampling of Atchafalaya Bay, Louisiana; the Mississippi Sound complex extending westward to Lake Borgne, Louisiana; and Florida Bay, Florida. The study consisted of the collection of water and sediment samples for chemical analysis, and collection of benthic infaunal samples.

From the NRDA perspective, this study offers little information to injury assessment efforts other than to document clean or mildly contaminated backgrounds at the selected locations. Of the 123 analyzed field samples, 57 were beyond the boundaries of the spill and the remaining 66 samples contained only partial PAH patterns or were clean (33 each of categories 6 and 7). TPAH50 ranged from 0 to 0.68 μg/L (ppb) in western Louisiana (Marsh Island). Following this sampling program, NGOM was implemented to resample the region on a tighter grid (5 mile interval) but absent any corroborating data, also yielded unmatched or clean samples, excepting at Gulf Shores (as in Figure 18).

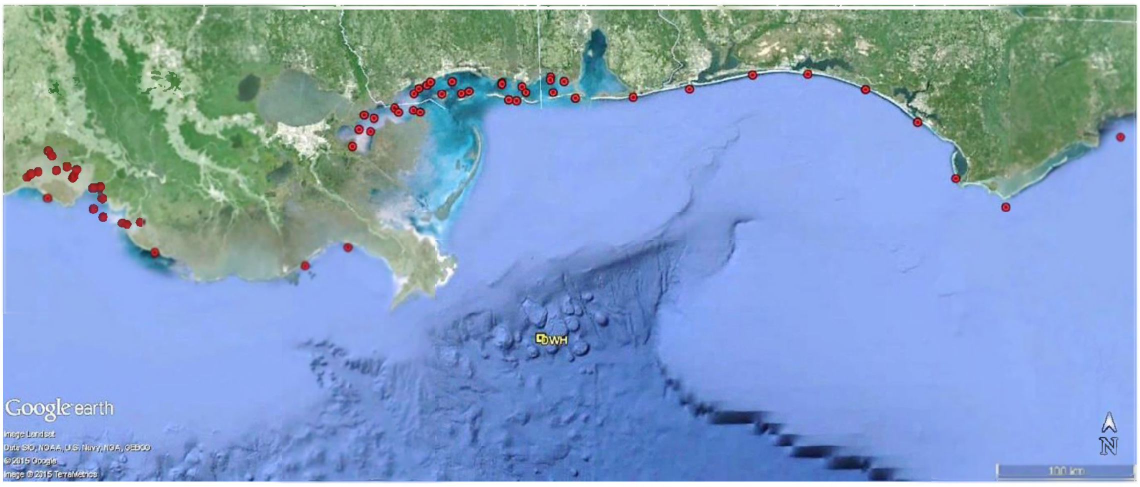


Figure 21. Distribution of samples from Shallow Subtidal Benthic and Water Baseline Plan

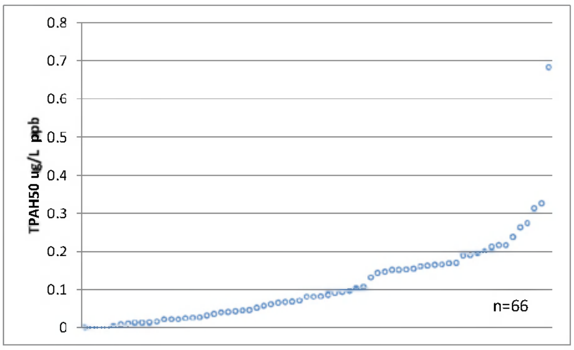


Figure 22. Distribution of TPAH50 (ppb) from Shallow Subtidal Benthic and Water Baseline Plan

Appendix 3 Intertidal Baseline Sediment and Water Sampling

Intertidal Baseline Sediment and Water Sampling (SRN 87) was a cooperative study to sample baseline waters, sediments and biota ***prior*** to oil encounters from Grande Isle LA to Key Biscayne FL.

Triplicate samples were taken with none matching MC252 oil. In summary, 30 "other oils" were reported with another 33 as indeterminate or clean. The remaining 90 samples were from beyond the boundaries of the spill area. TPAH50 ranged from 0 to 140 ppt (Biloxi beach).

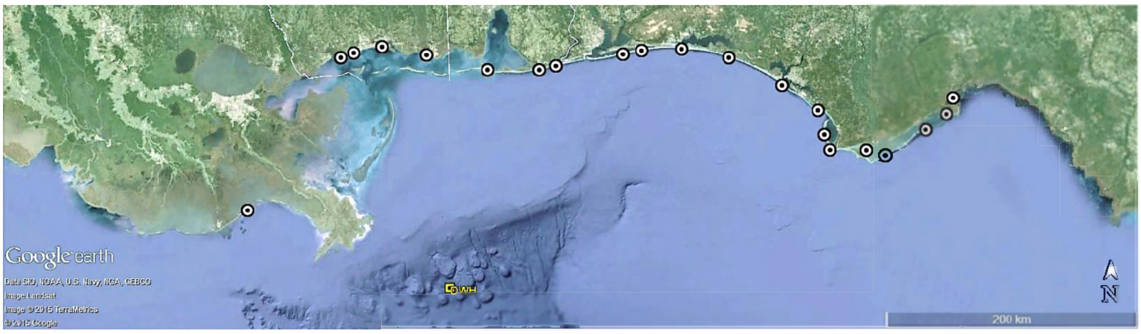


Figure 23. Distribution of samples from pre-oiling Intertidal Baseline (triplicate sampling, 21 sites).

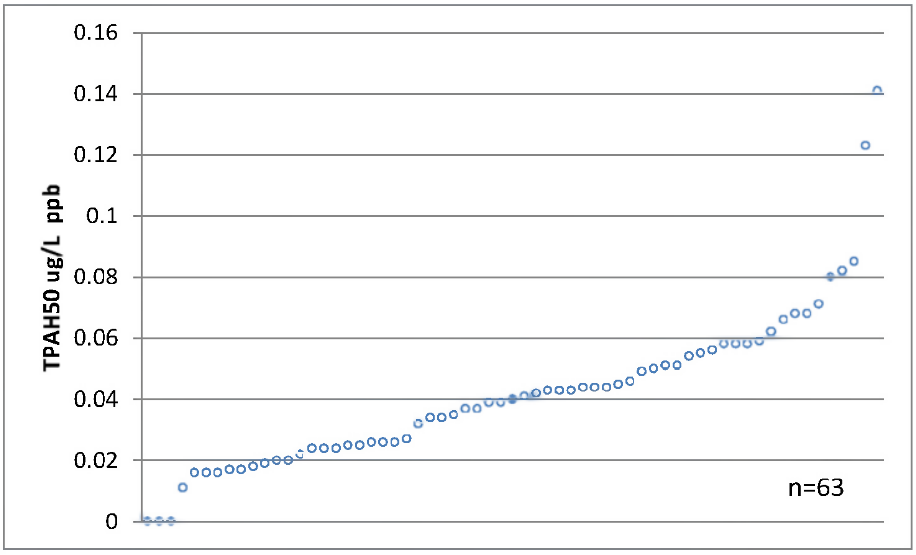


Figure 24. Distribution of TPAH50 (ppb) from pre-oiling Intertidal Baseline Plan.

Appendix 4 Organic Contaminants, Trace and Major Elements, and Nutrients in Water and Sediment Sampled in Response to the Deepwater Horizon Oil Spill

The US Geological Service also surveyed the shoreline and reported a very comprehensive data set (Nowell et al., 2011). The original dataset has not yet been obtained for forensic evaluation but from their final report:

> "Beach water and sediment samples were collected along the Gulf of Mexico coast to assess differences in contaminant concentrations before and after landfall of Macondo-1 well oil released into the Gulf of Mexico from the sinking of the British Petroleum Corporation's Deepwater Horizon drilling platform. Samples were collected at 70 coastal sites on the Gulf of Mexico between May 7 and July 7, 2010, to document baseline, "pre-landfall" conditions. A subset of these sites was resampled during October 4 to 14, 2010, after oil had made landfall on the Gulf of Mexico coast ("post-landfall") to determine if actionable concentrations of oil were present along shorelines.
>
> Few organic contaminants were detected in water; their detection frequencies were generally low and similar in pre-landfall and post-landfall samples. Only one organic contaminant, toluene, had significantly higher concentrations in post-landfall than pre-landfall water samples. No samples exceeded any human-health benchmarks, and only one sample exceeded an aquatic-life benchmark—the toxic-unit benchmark for polycyclic aromatic hydrocarbons (PAH) mixtures was exceeded in one post-landfall water sample from Louisiana. No exceedance was observed in the corresponding pre-landfall water sample at this site."

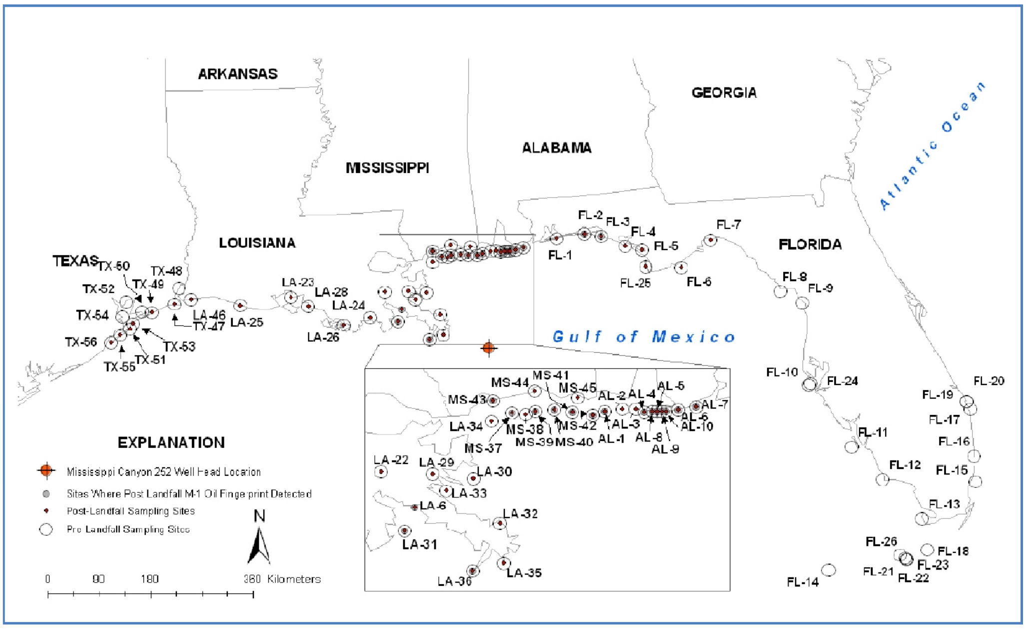


Figure 25. USGS monitoring sites (from Nowell et al. 2011).

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